## 10.2 FIRE HISTORY

A review of the fires that have occurred in the U.S. nuclear industry showed that, except for the 1957 fire at Rocky Flats, no contamination escaped from the accident sites via the ventilation system. During most of these events, operational personnel were present, automatic fire suppression systems controlled the fire and alerted emergency personnel, and the fire was so small that it burned out before discovery. The most significant fires involving the final high-efficiency particulate air (HEPA) filters of confinement ventilation systems have occurred at the Rocky Flats Plant.

In 1957, pyrophoric ignition of plutonium in a production line ignited combustible filters in the production box and spread from there via plastic window materials and other unknown combustible materials in the ventilation system to involve and destroy combustible filters in the final filter plenum. Some contamination was released during this event.[3] As a result of this fire, fire-resistant HEPA filters were researched, developed, and put into service by the nuclear industry.

In 1969, another fire occurred at Rocky Flats in a production line glovebox. The exact cause of this fire is unknown, but the area of origin included a storage cabinet that housed small, open metal containers of plutonium machine turnings. The cabinets, constructed of high-density pressed wood shielding material and plastic, were included in the production line to reduce radiation exposure to workers. Heat detectors originally installed in the glovebox were removed to the underside of the glovebox floor to accommodate the cabinet. A fire detector alarm alerted the fire department. When the firefighters arrived, the building was smoke-logged, indicating that the fire had escaped the confinement system. While the fire did not escape the site, localized contamination was detected on site.

The fire initially progressed along a production line (the north line) and, because of smoke-plugged filters that caused normal airflow reversal, spread across an interconnecting conveyor line to another production line (the center line). In a cross-conveyor line, the fire's progress stopped at a nonrated barrier that acted as a fire door. The fire was controlled in about 4 hrs by the fire department. The only contamination that escaped the confinement volume was tracked by the fire crews. No contamination was released from the final HEPA filter plenum. The extent of fire through the production line might have limited if the following factors had not contributed to its spread.

- The fire detectors were not in their original location (apparently the heat detectors were removed from the origin area to accommodate the scrap storage arrangement).
- Automatic fire doors were not installed at strategic junctions.
- An area-wide fire management system was not in place.
- Pyrophoric metal scraps were not contained in sealed containers.
- Nonflammable cabinets were not used to house pyrophoric scrap containers.

In response to this fire, the U.S. Atomic Energy Commission (AEC) instituted many new programs to increase fire safety at all contractor facilities operated for the government.[5, 6]

Because the major fire at Rocky Flats in 1969 started and quickly spread thorough an integrated glovebox network, the final HEPA filters failed due to excessive temperature.[7] This failure prompted a number of research investigations that eventually led to changes in glovebox and exhaust ventilation design. Key glovebox design changes included limiting their size and or separating longer units with fire doors. For the exhaust ventilation system, the high-temperature problem during fires was addressed by adding a water spray/demister system. Tests at Lawrence Livermore National Laboratories (LLNL) showed that combustion-heated air at 820 degrees Celsius could be cooled to 175 degrees Celsius with water sprays and demisters. These systems were widely adopted in DOE facilities and are recommended in DOE Technical Standard 1066[8] and NUREG-1718.[9]

The causes of fire in nuclear facilities is another subject, but electrical sources, spontaneous ignition of pyrophoric metals, and ignition of flammable gases and vapors are among the most common events found.

It is notable that current regulations mandate automatic sprinkler protection for electrical cable trays, tunnels, shafts, chases, cable spreading rooms, and penetrations. National Fire Protection Association (NFPA) Standard 803, "Fire Protection for Nuclear Power Plants," [10] contains the current complement of recommended practices for fire protection in nuclear power plants, including guides for fire prevention programs and considerations of fire risk and prevention for new construction. Items missing from this standard include guidelines for fire prevention and long-term fire protection during and after power plant decommissioning. Tables 9.2 and 10-1.2 of this standard respectively detail general criteria for fire detection and suppression installations in all facilities of a power plant.

Prior to the Browns Ferry fire, the use of water on electrical fires was not considered a safe practice. Following the Browns Ferry fire in 1975[a,b] (see USNRC NUREG-0050, "Recommendations Related to the Browns Ferry Fire," February 1976), in USNRC NUREG-0050, February 1976,[11] Factory Mutual (now FM Global) and other organizations performed studies to test the use of water in electrical spaces (see EPRI NP-1881[12] and EPRI NP- 2660).[13] In addition, Sandia National Laboratories (SNL) performed tests on cable tray protection schemes (see USNRC NUREG/CR 3656,[14] NUREG/CR-2377,[15] and NUREG/CR-2607,[16] as well as SNL reports SAND 83-2664, SAND-81-7160,[17] and, SAND 82-0431).[18] These studies by Factory Mutual and other organizations showed that fighting fires in grouped cables could be accomplished efficiently with the use of water (these tests were done on unenergized electrical cables, however, the conclusions on the use of water as an efficient extinguishing agent were confirmed). Following the Browns Ferry fire and the tests performed by Factory Mutual, SNL, and others, the inhibition against using water to put out fires in all spaces with electrical equipment seemed to subside, and fire protection engineers made more deliberate assessments of the type of electrical occupancy when considering use of water as a fire suppressant.[19,20]

On July 2, 1980, another incident involving HEPA filters occurred at Rocky Flats. In this event, a high-temperature excursion occurred in the final filter plenum of a waste disposal incinerator. Water deluge was initiated in the plenum, and the incident was secured. Investigators determined that a bypass valve of a heat exchanger failed open, allowing metal fines from corrosion processes and nitric acid collection by the first filter bank. It was further found that nitric acid exothermically reacts with the urethane seals of the HEPA filters, which could then ignite the metal fines. Water deluge reduced plenum temperature, and the fire department "mopped-up."

No flames were ever observed during the incident. The first three stages of the four-stage filter array were severely damaged by combined excess heat and water exposure. The remaining stage was intact, allowing no contaminants to escape the confinement plenum of the incinerator.[21] Moreover, improvements in detection system technology and in fire-resistant materials were significant in that decade. It is probably safe to say that the two production line fires could not be repeated in the systems operating in the current decade. The question posed by the 1980 incinerator fire is: "What effect does water exposure have on HEPA filter stability and endurance in a fire environment? It is known that any water damage to the filters resulted from a water spray system because fire department activities did not include water application.

In the spring and summer of 2000, the DOE complex experienced wildland fires at the Los Alamos National Laboratory (LANL), Idaho National Engineering and Environmental Laboratories (INEEL), and Richland, Washington, sites. These fires, particularly the one at LANL, impacted the ventilation systems at the site by clogging intake filters and causing evacuation of all but essential personnel on those sites.

## 10.3 CODES AND STANDARDS

Decisions regarding the extent and nature of fire safety features for confinement ventilation systems are predicated to a significant degree on the regulatory environment governing the facility. That environment can be characterized as being "external," for those facilities regulated by the U.S. Nuclear Regulatory Commission (USNRC) or "internal" for those facilities owned by Government entities like the DOE. The applicability of any fire safety criteria to a